corrected monolithic mirror would be a reasonable choice for the VLT. At the time of the NTT completion which might also correspond to the start of the construction of the VLT, enough experience will have been acquired (including tests on a real telescope) so that the extrapolation of the NTT technology up to a diameter of about 8–10 m will be possible. The corresponding blank will not necessarily be a solid meniscus but will more likely be a hollow honeycomb structure either made out of glass or metal. There too, the important investigation on metal mirrors carried out in the framework of the NTT project may have an important impact on the VLT.

As a result of these various considerations, option (c) seems at the moment the most attractive. A similar conclusion was also reached by ESO's Scientific and Technical Committee at its meeting on 8 November, 1983, where it was clearly recommended that ESO should consider its VLT as a limited array of large telescopes, and start as soon as possible on the definition of the first of its 8–10 metre elements.

Interferometry is only meaningful if some of the telescopes are mobile. Again, the cost aspects of making a telescope mobile but at the same time stable to high accuracy, need be studied. Alternatively, at least in the IR it may be profitable to do interferometry with a combination of fixed 8 m and mobile smaller telescopes. This point also needs further study.

Another set of studies which started a few months ago is that related to the choice of a site for the VLT. The absolute requirement for the site for an expensive telescope to be operated at its highest efficiency is excellent seeing. This is already the case when only standard applications like various types of spectroscopy, or faint object observation, or infrared photometry are considered. It is still more strongly the case in interferometric applications where the signal-to-noise ratio may vary with as much as the 3rd or 4th power of the seeing parameter. A second and important requirement is very low humidity for IR studies; regions with strong winds are also to be avoided.

One should also note that the selection of a site is not without consequence for the definition of the concept. For instance it may not be obvious to find an excellent site on which both a coherent long baseline array and the large telescopes can fit together without affecting the performance of one or the other.

A workshop on "Site Testing for Future Large Telescopes" was held very recently (Oct. 4–6) at ESO in Chile in order to "review what is being done to test and compare the very best sites in the world and what more should be done in the coming few years". Meteorological observations and measurements of total precipitable water content have already been started in a few very dry sites in northern Chile. Seeing studies should be taken up next year if these first measurements are satisfactory.

Together with the measurements for site selection, technical studies are being initiated, as well as a detailed discussion of the implications on the scientific objectives. Suggestions and research proposals from institutes in the ESO countries on subjects related to the VLT (either on concepts, technology, instrumentation, or in more specific areas such as wide band high efficiency coatings, image slicers, fiber optics . . .) will be sollicited.

A New Class of Cataclysmic Variables: the Intermediate Polars

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Introduction

Several newly discovered hard X-ray sources (kT > 2 keV) were identified with binary systems, characterized by an orbital period of 3 to 4 hours and by strong emission lines in the optical and ultraviolet superimposed on a blue continuum. (Fig. 1, 2). Moreover, these systems exhibit strong periodic and coherent variations on a time scale of ten minutes, the so-called "pulsations", with a full amplitude from 10 to 40%. (Fig. 3). These

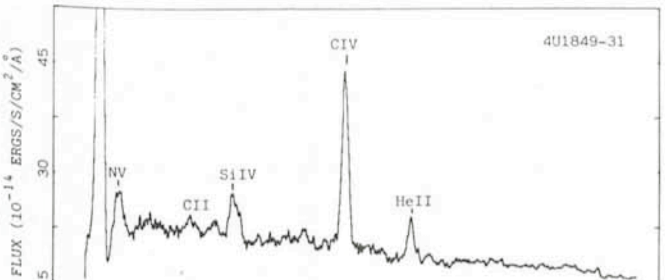

Fig. 1: *Average IUE spectrum of 4U1849–31.*

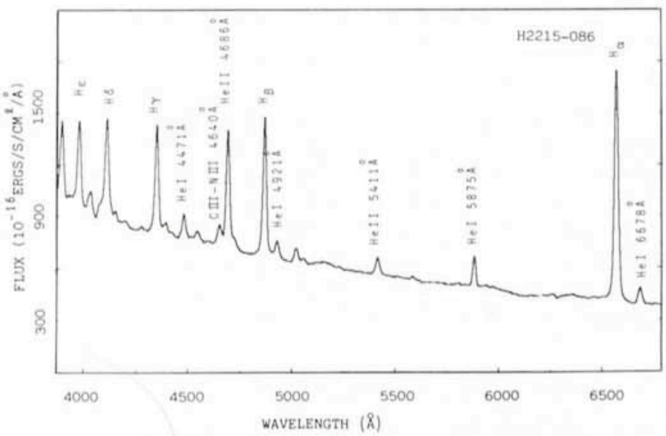

Fig. 2: *Average optical spectrum of H2215–086 obtained at the 3.6 m telescope using the IDS attached at the Boller and Chivens spectrograph. Note the strong He II 4686 Å line.*

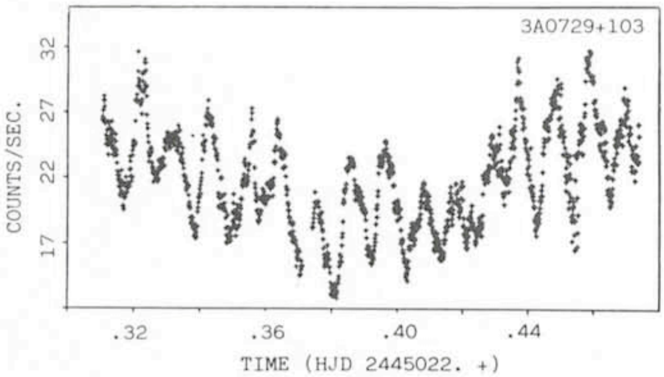

Fig. 3: *Light-curve of 3A0729+103. Strong pulsations with a 15.2-min period are observed. (Warner, B., 1983, IAU Colloquium No. 72, p. 155, reproduced with the author's permission).*

sources are related to the class of cataclysmic variables: close binaries in which a red dwarf secondary fills its Roche lobe and transfers matter via an accretion disk onto the surface of a white dwarf (see Ritter, H., 1980, *The Messenger* No. 21). The novae and the dwarf novae are well-known members of this class. Some results concerning individual objects of these types are presented in several articles published in the *Messenger* (Drechsel, H. et al., 1983, No. 32; Stolz, B., 1981, No. 26; Drechsel, H. et al., 1980, No. 22; . . .). The peculiar sources discussed here are called "intermediate polars". The origin of this name will be justified in a following paragraph. Optical outbursts similar to those observed in novae or in dwarf novae have not yet been recorded in intermediate polars, besides low states (1 to 3 magnitudes below the usual value) that have been discovered in two sources from the Harvard plate collection.

Up to now four objects of this new class have been discovered, showing optical pulsations. Two of them also exhibit X-ray pulsations with similar periods (Table 1). A detailed study of H2252-035 and 4U1849-31 has revealed the presence of two nearby periods in the optical pulsations, so that their beat period corresponds to the orbital one.

Table 1. Periods observed in intermediate polars

Source	Orbital period	Pulsation periods Optical	X-ray
H2252-035 (AO Pisc)	3.59 h	14.2 min 13.4 min	13.4 min
4U1849-31 (V1223-Sgr)	3.36 h	13.2 min 14.2 min	?
H2215-086	4.03 h	20.9 min 19 or 23 min ?	?
3 AO729+103	3.75 h	15.2 min	15 – 17 min

In the following paragraphs I shall give an interpretation for these pulsations, discuss the existence of an accretion disk and an accretion column and describe one of these objects, H2215-086, in more detail. A review of the properties of the intermediate polars is given by Warner (1983, IAU Colloquium No. 72, p. 155, and 1983, Proceedings of "Cataclysmic Variables and low mass X-ray Binaries", Cambridge, Mass., in press) and by Mouchet (1983, IAU Colloquium No. 72, p. 173).

The Oblique Magnetized Rotator Model

X-ray Pulsations

The pulsations described above are similar to those detected in other X-ray binaries in which the compact accreting star is a neutron star, like Cen X-3, 4U1626–37 . . . (Ilovaisky et al., 1978, *The Messenger,* No. 14). The current model for these sources consists of a magnetized compact object with a magnetic axis non aligned with the rotational one. The accreting matter is channelled along the magnetic field, and the released gravitational energy of the inflowing matter, radiated in X-rays, leads to an anisotropic X-ray emission modulated with the rotational period of the compact star (like the beam of a lighthouse). This model was proposed to explain the pulsations observed in the intermediate polars, based on the fact that they are present in X-rays for, at least, two objects.

Optical Pulsations

The X-ray pulsations find a direct explanation with the model described above. But, what about the optical pulsations? A detailed observational study of the two sources H2252–035 and 4U1849–31 could give clues for their origin. (Motch, C., and Pakull, M., 1981, *Astronomy and Astrophysics* **101,** L9, Van Paradijs, J. et al., 1983, Proceedings of "Cataclysmic Variables and low-mass X-ray Binaries", Cambridge, Mass., in press). Fast photometry of these objects was carried out at the 90 cm Dutch telescope using the Walraven photometer which allows to measure the flux simultaneously in five pass-bands ranging from 3200 Å to 5500 Å and then to evaluate the energy distribution of the two optical pulsations present in these systems. For H2252–035, the pulsation at the shortest period exhibits a steeper distribution ($F_\lambda \sim \lambda^{-4.5}$) than the 14.2 minutes pulsation ($F_\lambda \sim \lambda^{-3.3}$). Both pulsations in 4U1849–31 have the same behaviour, similar to the 14.2 minutes pulsations of H2252–035. On the basis of these results, it was possible to suggest an explanation for the optical pulsations: the steepest one observed in H2252–035 would be due to a hot spot associated to the polar cap on the white dwarf while the other kind of pulsations show an energy distribution similar to the one expected from an X-ray heated region. If the reprocessing of

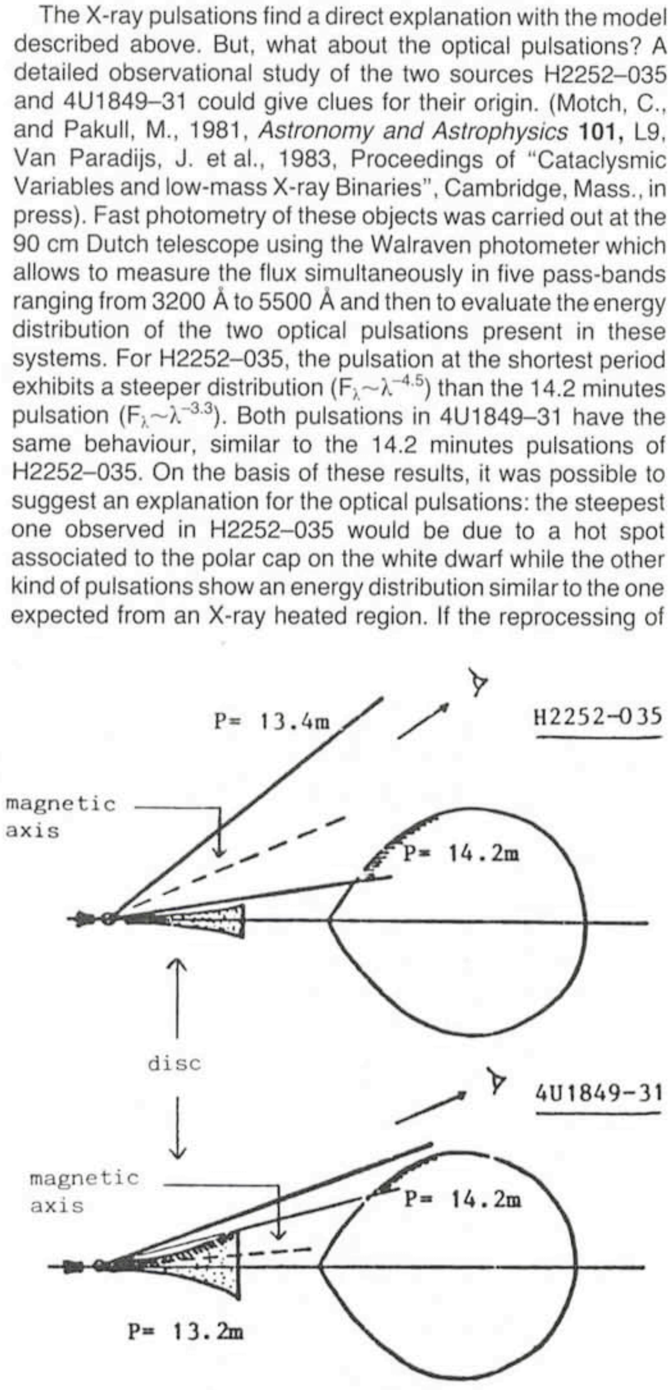

Fig. 4: *Geometrical model explaining the pulsations in H2252–035 and 4U1849–31. The hatched parts correspond to the X-ray illuminated regions. (By permission of the author: B. Warner, Proceedings of "Cataclysmic Variables and Low Mass X-ray Binaries", Cambridge, Mass., 1983, in press.)*

the X-rays occurs on an axisymmetric region (relatively to the rotational axis), the disk, for instance, the period of the optical pulsations is equal to the rotational one, while if the illuminated region is fixed in a frame rotating with the orbital period (like the secondary hemisphere or a bulge on the disk) the observed period is the beat period between the rotational and the orbital ones. Since the observed beat periods are greater than the rotational ones for both sources, the white dwarf motion is retrograde. Fig. 4, from Warner (1983), summarizes this rather long but simple explanation. Moreover this geometrical model accounts for other observational facts such as the phasing of both the pulsations and the temporary disappearance of the 14.2 min. pulsation in 4U1849–31 (from time to time the outer region of the disk intercepts the whole low inclination magnetic beam). Of course, for 4U1849–31, the discovery of an X-ray periodicity at 13.2 min would be a strong support for this explanation. A similar study of the two other sources must be done as soon as possible. For H2215–086, a first attempt of such an interpretation was done from spectroscopic data.

Clues for a Disk or an Accretion Column?

In high-inclination cataclysmic systems the existence of an accretion disk is revealed by the presence of eclipses and emission lines showing double-peaked profiles characterizing a rotational disk. These features are not observed in any of the objects discussed here for which the inclination angle is probably too low. Nevertheless it is possible to detect a disk by comparing the energy distribution of the continuum with accretion disk models. The simplest one is the optically thick disk model in which each annulus radiates the local gravitational energy as a black-body emission of temperature decreasing towards the outer parts. (For more details, see Bath et al., 1980, *Monthly Notices of the Royal Astronomical Society,* **190,** 185). It is possible to explain the energy distribution from UV to infrared with such a disk for H2252–035 and 4U1849–31, but this requires a rather extended disk and a high accretion rate. This last parameter leads to an X-ray luminosity largely higher than the observed one. This discrepancy remains even if other contributions are considered (the reprocessed X-ray flux, the white dwarf, the secondary . . .)

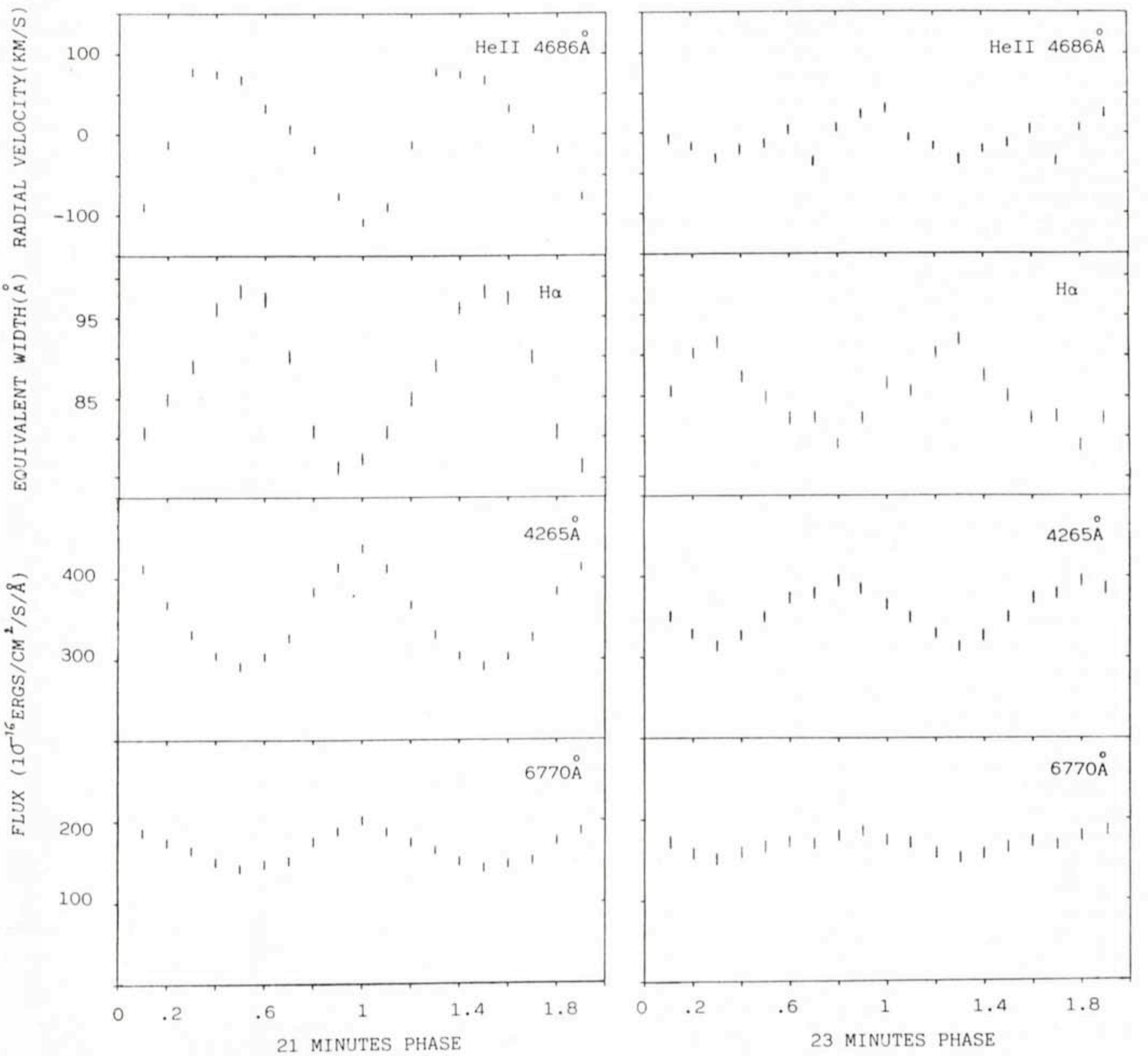

Fig. 5: *Fluxes at 6770 Å and 4265 Å, equivalent widths of Hα, radial velocities of He II folded with the 21-min period (left) and with the 23-min period (right) present in H2215–086.*

Note that the amplitude of the optical pulsations also implies an X-ray luminosity, responsible for the reprocessed flux, greater than the X-ray measurements. This leads to assume that a large fraction of the hard X-rays is rethermalized at lower energy. Detection of very soft X-rays or extreme UV radiation could solve the mystery of the missing X-ray radiation.

Though the detection of an accretion disk is not quite well established, we have seen that it seems reasonable to affirm its existence. On the other hand, the proposed interpretation for the pulsations requires a white dwarf sufficiently magnetized to favour an anisotropic accretion along the magnetic field. But other possible signatures of a magnetic field (i.e. linear and circular polarization, Zeeman components, cyclotron lines) have been seeked unsuccessfully in these systems. Such properties have been detected in other cataclysmic systems called "polars" in which the magnetic field of the white dwarf was evaluated to be equal to $3\ 10^7$ Gauss. In these sources, the extended magnetosphere prevents the formation of an accretion disk. Moreover, a magnetic coupling between both companions occurs, leading to a synchronization of the rotation of the white dwarf with the orbital period. In the intermediate polars, the magnetic field would be too weak to achieve this synchronization and to observe its direct effects. Besides, we expect to observe a polarized radiation in infrared. Unfortunately, no such measurements have been done up to now. I think that now the reader begins to understand the origin of the name "intermediate polars". He also has to know the existence of a small group of cataclysmic variables which exhibit pulsations at very short periods, and consist of two novae DQ Her and V533 Her and a dwarf nova AE Aqr (respectively with periods 71s, 63s and 33s). Only one, AE Aqr, was detected in X-rays and shows X-ray 33s pulsations. The magnetic oblique rotator model was also suggested for these systems. But recently the disappearance of the 63s pulsations in V533 Her cast serious doubt on such an interpretation. These fast rotating objects are thought to have a weakly magnetized white dwarf ($B < 5\ 10^5$ Gauss), although no direct evidence for such a field is found. With respect to their rotational period as well as the strength of their magnetic field, the "intermediate polars" are therefore located between the DQ Her type objects and the AM Her type systems (polars).

A Puzzling Source: H2215–086

While a satisfactory model has been proposed for 4U1849–31 and H2252–035, the X-ray source H2215–086 classified as an intermediate polar on the basis of strong optical pulsations with a 21-minute period does not seem to enter quite well in a similar frame. It differs slightly from the two previous sources by showing very strong He II lines, a rather flat UV continuum and pulsations with a huge amplitude (40% in V). Previous observations suggest the presence of a 23-minute period (Patterson, J., and Steiner, J. E., 1983, *Astrophysical Journal,* **264,** L61). In order to precise the nature of this system, we have carried out spectroscopic observations at the 3.6 m telescope using the IDS detector. Unfortunately, the wind was blowing too strongly at the 1 m telescope to get simultaneous photometric data. Then, after four hours of observing time we were requested by a careful astronomer on duty to shut the dome of the 3.6 m. Despite the bad wheather, these observations provided a lot of information. Thanks to very short-exposure spectra (30 seconds) with a 12 Å resolution, it was possible to detect the 21-minute pulsations in the continuum and the strongest emission lines. Search for periodicity in these individual spectra reveals clearly the 21-minute period and an additional period at 23 minutes corresponding to the beat period with the orbital one (4 hours). A possibly false pulsation at 19 min could also be present, maybe due to the total duration of the observations.

To increase the signal to noise ratio we have folded the spectra with the 21-min and 23-min periods and then determined the variations of the continuum at several wavelengths and of the Balmer and He II λ 4686 lines (intensities, equivalent widths and radial velocities) (Fig. 5). Surprisingly, the results, though well established, are rather difficult to interpret when gathered together. Let us discuss some of them. Both pulsations exhibit an energy distribution F_λ in λ^{-2} on the wavelength range 4200–6800 Å and at the maximum of the orbital period, the 23-min pulsation is at minimum when the 21-min pulsation is at maximum. In the context of the geometrical model described above and assuming that at the orbital maximum the red dwarf companion is behind the white dwarf, this would imply a pulsation arising from the accretion column while the other one is due to a heating effect. But how to explain the energy spectrum? Now, taking into account the strong variations of the radial velocities of the lines with the 21-min period (receding motion when the flux is minimum), this suggests a region of line formation in the column (the free-fall velocity being the dominant motion) and a heating origin for the 21-min pulsation, a conclusion incompatible with the previous ones based on the phasing of the 23-min and 21-min pulsations! It is obvious that no clear description similar to the one proposed above is satisfactory. The study of the spectroscopic variability of 4U1849–31 and H2252–035 has not yet been completed. It is urgent to do so in order to confirm the previous interpretation and to clear up to the confused and puzzling results of H2215–086.

Conclusion

Though the class of the intermediate polars is very little crowded, the similar properties of the four objects incite to consider them as a special group. Nevertheless, it might be possible that further observations emphasize different behaviours or on the contrary strengthen a unique model for these systems. The discovery of new pulsating sources, either from X-ray or optical observations would allow to clarify the nature of these peculiar objects. Let us hope that bad weather conditions will not prevent us from achieving these crucial observations.

Acknowledgements

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List of Preprints Published at ESO Scientific Group

September-November 1983

276. G. Chincarini: HI Content in Cluster and Supercluster Galaxies. COSPAR/IAU Symposium in Rojen, Bulgaria. September 1983.
277. M. Rosa and J. Solf: On the Internal Kinematics of the Giant Extragalactic HII Complex NGC 604. *Astronomy and Astrophysics.* September 1983.
278. G. Contopoulos: Theoretical Periodic Orbits in 3-Dimensional Hamiltonians. *Physica D.* September 1983.
279. A. C. Danks, W. Wamsteker, P. A. Shaver and D. S. Retallack: A Near-Infrared Study of the Region l = 305°. *Astronomy and Astrophysics.* September 1983.